



Depredation of Crop Caused By Monkeys nearby Shivapuri-Nagarjun National Park, Kathmandu, Nepal

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Abstract

Macaca mulatta, and *Macaca assamensis* are common monkeys in Nepal. The *Macaca assamensis* was categorized as 'Vulnerable' under IUCN Red List. The habitat of the monkey was disturbed because of human interference and hence the consequence is frequent damage of human's properties. However, there was limited study regarding the crop damage caused by monkeys in Nepal. Therefore, this study was objectively conducted to assess the damages and their spatial distribution caused by Monkeys nearby Shivapuri-Nagarjun National Park and also find the causes of interface between humans and Monkey. Four sites were visited and 120 house hold survey was done to collect the primary data. The GPS coordinates of the spatial distribution of damages were recorded. Secondary information about the damages was collected from 2019 to 2022. Descriptive and statistical analysis like trend analysis, principle component analysis and mapping of distribution of damages was done. The result showed that, the highest damage of the maize at Nayagaun, Thulogaun with 650 Kg while this was the lowest around 280 Kg. Similarly, the highest maize damage at Naagarjun, Gufagairi, Sarung danda was 400 Kg while the highest record of crop damage at Raniban, Ichangu Narayan was 190 Kg. The distribution map showed that there were 12 locations of maize damage over 450 kg at Nayagaun, Thulogaun. Similarly, the map of Goldhunga showed 17 places having medium damage (120-350 kg), 28 places of low damage (50-120 kg) while the 5 places of very low damage (<50 kg). The principle component analysis showed the causes of interface between humans and monkeys. The use of catapult in Nayagaun, Thulogaun, shout and charge threat in Naagarjun, Gufagairi, Sarung danda and in Raniban, Ichangu Narayan were the most influencing factors of this interface. This research will be useful for scientific community and policy maker.

Keywords: Macaca; Principal Component Analysis; Catapult; Shout; Charge; Troops; Damaged

Introduction

Long-tailed macaques (*Macaca fascicularis*) are the most frequently seen species among the thirteen species of primates in Thailand and they were recently reported at 91 locations [1-3]. In comparison, only nineteen, twelve, eleven, and nine

locations were observed for rhesus (*M. mulatta*), pigtailed (*M. nemestrina*), stump-tailed (*M. arctoides*) and Assamese macaques (*M. assamensis*) respectively [3] Macaques (genus *Macaca*; Family: Cercopithecidae) are ecologically extremely adaptive primates which are distributed more widely than any other non-human primate genus.

Two species of macaques have been reported in Nepal namely Rhesus macaque *Macaca mulatta* (Zimmermann, 1780) and the Assamese macaque *Macaca assamensis* (McClelland, 1840) but latter one is the less well researched nonhuman primate in Nepal [4] and was categorized as 'Vulnerable' in 2007 under IUCN Red List of Threatened Animals. *Macaca assamensis* is categorized as 'vulnerable' and is one of the protected mammals by the National Parks and Wildlife Conservation Act 1973 of Nepal [5,6]. Its study was done in Makalu- Barun area and also in Langtang area. *Macaca assamensis* was first recorded in 1985 in Shivapuri Nagarjuna National Parks and thereafter remained unknown long time. It was reported that total 213 Assamese macaques (*Macaca assamensis*) were encountered in 9 groups within the total area surveyed of 113 km² at Langtang National Park [7,8].

Assamese monkeys are shy, timid, and less aggressive to human beings in comparison to the rhesus monkey. They are arboreal, terrestrial, and omnivorous animals with multi-male and multi-female social troops [9]. With the rapid increment in human population in and around the monkey's habitat, the relationship between these primates has turned into enmity. In fact, human beings are sole blame of destructing habitat of monkey. Human population growth and activities like deforestation, agriculture, and urbanization lead to an never ending encroachment on wildlife habitats. The interface of wildlife habitat and human use dominated landscape has become grounds for a wide range of human-wildlife conflict [10]. Human non-human primates' conflict is increasing to the developing countries than developed countries due to greater biodiversity and lack of prevention measures such as farm fences, livestock guard [11]. In south Asia conflicts between humans and the Rhesus macaques (*Macaca mulatta*) seems to increase. In Uganda, the cost of crop raiding by primates and guarding varied from US\$ 96-519 per household per year. Likewise, in Kenya, crop raiding costs US\$ 200-400/ households/year [12] which is a large amount of money in comparison to their daily income.

There are very few studies about damages causes by Assamese monkey nearby Shivapuri Nagarjun National Park. Several damages caused by *Macaca assamensis* were observed nearby Sivapuri Nagarjuna Shivapuri National Parks, but there is not any reliable record of these damages. Local people have been facing the problem caused by *Macaca assamensis* nearby this National Park. At the same time its damages distribution is not only limited in one location but also in several parts of National Park as well, but the spatial distribution of such damages is not so far mapped. Thus, this study was objectively done to assess the damages caused by Monkeys, spatial distribution of damages and explore the causes of interface between humans and Monkey nearby Shivapuri-Nagarjun National Park.

Materials and Methods

Study Area

Shivapuri-Nagarjun National Park (SNNP), near Kathmandu, Nepal, is comprised of two isolated forest tracts, Shivapuri and Nagarjun. Nagarjun forest covers 16 square kilometers and is immediately adjacent to the northwest boundary of Kathmandu city. Geographically, Shivapuri is located between 27° 45' to 27° 52' North and 85° 16' to 85° 45' east. Nagarjun is located between 27° 43' to 27° 46' north and 85° 13' to 85° 18' east.. The main range of the hill runs in the east-west direction with the highest peak at Jamacho (2100 m), which rises abruptly from the floor of Kathmandu valley (1350 m) (Figure 1).

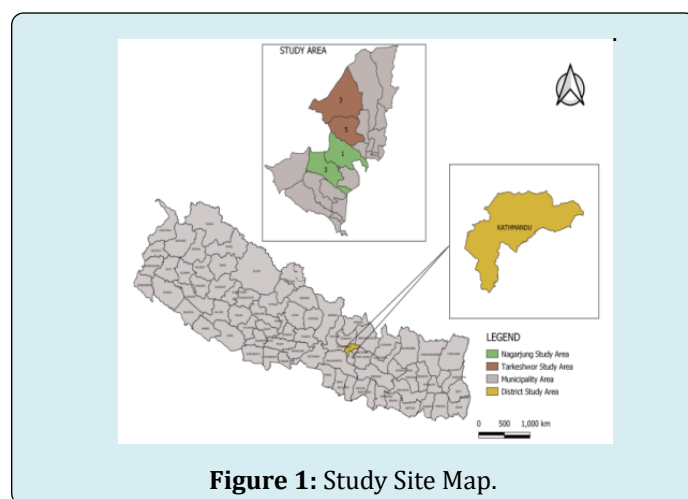


Figure 1: Study Site Map.

The temperature of study site ranges from 3.5°C (January) to 30.2°C (August). Similarly, relative humidity in December is maximum (91.5%) and in May it is minimum (78.0%). Likewise, rainfall in August was maximum i.e., 339.9 mm while it was a maximum of 552.8mm in July. There are four types of forests namely *Schima wallichii* forest, mixed broadleaved forest, pine forest, and dry oak forest in Nagarjun hill. There are few small patches of the grassy meadow (Nagarkoti 2006). These forests are home for sixteen species of herpetofauna including *Naja kaouthia*, *Ophipagus Hannah*, *Trimeresurus albolabris*, *Japulura variegata* are recorded from Nagarjun forest among them *Megophrys parvais* most common among amphibians and *Calotes Versicolor* common among reptiles. Many Bird species including Kalij Pheasant (*Lophura leucomelanos*), Yellownapes (*Picus spp.*), Barbets (*Megalaima spp.*), Green-billed Malkoha (*Phaenicophaeus tristis*), Owlets (*Glaucidium spp.*), Himalayan Griffon (*Gyps himalayensis*), Harriers (*Circus spp.*), Drongos (*Dicrurus spp.*) Thrush (*Monticola spp* and *Myophonus spp.*) Tits (*Parus spp.*), Nuthatch (*Sitta spp.*), Bulbul (*Hypsipetes spp.*), laughing thrush (*Garrulax spp.*), Babbler (*Pomatorhinus spp.*) and many species of wablers [13,14].

Data Collection

The primary data were collected using site visit, group discussion, household survey and resource assessment. Similarly the secondary data were collected from report and published papers.

Site visit: The seasonal calendar showing the crop like wheat, maize, paddy etc. and calendar of damage was prepared. The visit was concentrated based on these calendars. The checklist was prepared to note the damages during the visit time, photographs and videography of damages was captured.

Group discussions: Total 4 group discussion was organized with different groups. Specifically, the group discussion was done with office staffs of National Park, victims caused by monkeys, authority of ward office and supportive organization. The causes of damages were also be recorded. For this the checklist was prepared and tested before going to field.

Household survey: List of household damages caused by Monkey was prepared. Among them 120 households were surveyed to collect the data related to damages caused by monkey. The household survey was including the types of damage, time of damage, quantity of damage, season of damage, year of damage, monetary value of damage, area of damage. Damage of 3 years was collected using the call back method. The causes of damages were recorded. For this the checklist was prepared.

Resource assessment: GPS coordinate of location of damages was recorded and at the same time coordinates was categorized according to types time of damage, quantity of damage, season of damage, year of damage, value of damage, area of damage.

Key informant interview: Experts, Government authority, local people, policy maker. Total 20 key informant interviews were taken. The causes of damages were also recorded. For

this checklist was prepared.

Secondary data collection: Trend of damage, record of compensation, record of damages, and location of damages were collected from published and unpublished documents available in National park office, newspaper, news etc. Required data and information was collected from literatures, relevant books and paper, spokesperson of rural municipality, operational plan of forest users and libraries, etc.

Data analysis: The collected data was analyses using statistical, spatial and unitary method. The statistical analysis was done using descriptive tools. The damages and its value were analyzed using unitary method to quantify the total damages. The mapping of damages caused by monkey was done and categorized based on size of damage, location of damage, density of damage. The Principle component analysis was done to find the major causes and their contribution in interface between monkey and people nearby Shivapuri-Nagarjun National Park.

Results

Damage caused by Rhesus Monkey (*Macaca mulatta*) at Different Sites

The descriptive statistics were performed to show average crop damage (kg) according to fiscal year. It was recorded that, mean with standard error, standard deviation, maximum and minimum values were 639.2±372.10, 832.05, 2080 and 78 respectively at Ichangu Narayan site. Similarly, mean with standard error, standard deviation, maximum and minimum values were 253.33±153.76, 266.33, 80 560 respectively. These values were varied according to fiscal year (Table 1).

Villagea	Maize damage (Kg) in 2019/2020			
	Mean ± SE	Sd	Min	Max
Goldhunga	639.2±372.10	832.05	78	2080
Ichangu Narayan	253.33±153.76	266.33	80	560
Maize damage in 2020/2021				
Goldhunga	710.80±149.88	1226.87	60	8000
Maize damage in 2021/2022				
Goldhunga	476±124.71	394.38	120	1360

Table 1: Descriptive Statistic of Crop Damage.

Trend of Compensation of Crop Damage

The damage caused by monkey was varying in place to place and compensation was paid by Shivpuri Nagarjun

National Park accordingly. According to report of national park, total 3 families each in Goldhunga and Ichangu Narayan were paid the compensations US \$ 600 and US\$ 617 as the damages evaluated 600 and 617 kg respectively in these sites

in year 1029/2020. Similar compensation was paid based on the evaluation of park's authority. It was the highest paid

about US\$ 38000 to 10 families in Goldhunga in 2020/2021 (Table 2).

Year	Site	No of families got compensation	Evaluated damage kg	Compensation US\$
2019/2020	Goldhunga	3	600	600
	Ichangu Narayan	3	617	617
2020/2021	Goldhunga	66	31214	38000
	Ichangu Narayan	Data not available		
2021/2022	Goldhunga	10	4760	40000

Table 2: Compensation to Damage and Loss caused by Monkeys.

Spatial distribution of Damage caused by Monkeys

The crop damage caused by monkey was categories into 5 main types. These are very high damage ranging from greater than 450 Kg; High damage ranging from 350 Kg to 450 kg; Medium damage was ranging from 120 Kg to 350 Kg; Low damage ranging from 50 Kg to 120 Kg. and very low damage was ranging from 20 Kg to 50 Kg. Out of these

studied area Tarakeshwor-3, Tarakeshwor-5, Nagarjun-1, and Nagarjun-3, Thulo Gaun of Tarakeshwor-3 which bore very high damage area and in Nagarjun-1 Raniban, Ichangu Narayan was high damage, Nagarjun-1, Nagarjun-3 (Gufa Gairi, Sarung Danda), Tarakeshwor-5 (Gol Dhunga) was medium damage, Nagarjun-1, Nagarjun-3, Tarakeshwor-5 was also bore low damage in some place. Tarakeshwor-5 also bore very low damage in some place which was little bit far from the SNNP (Figure 2).

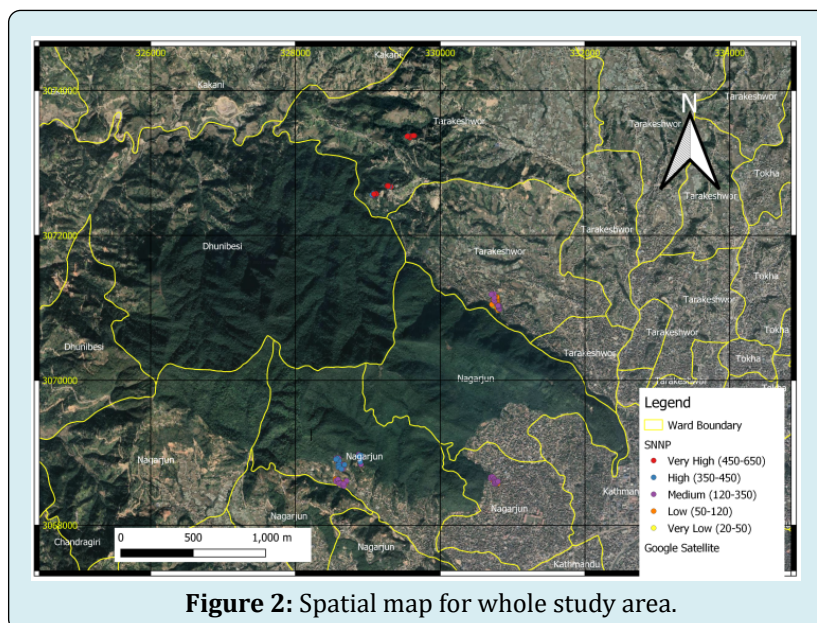
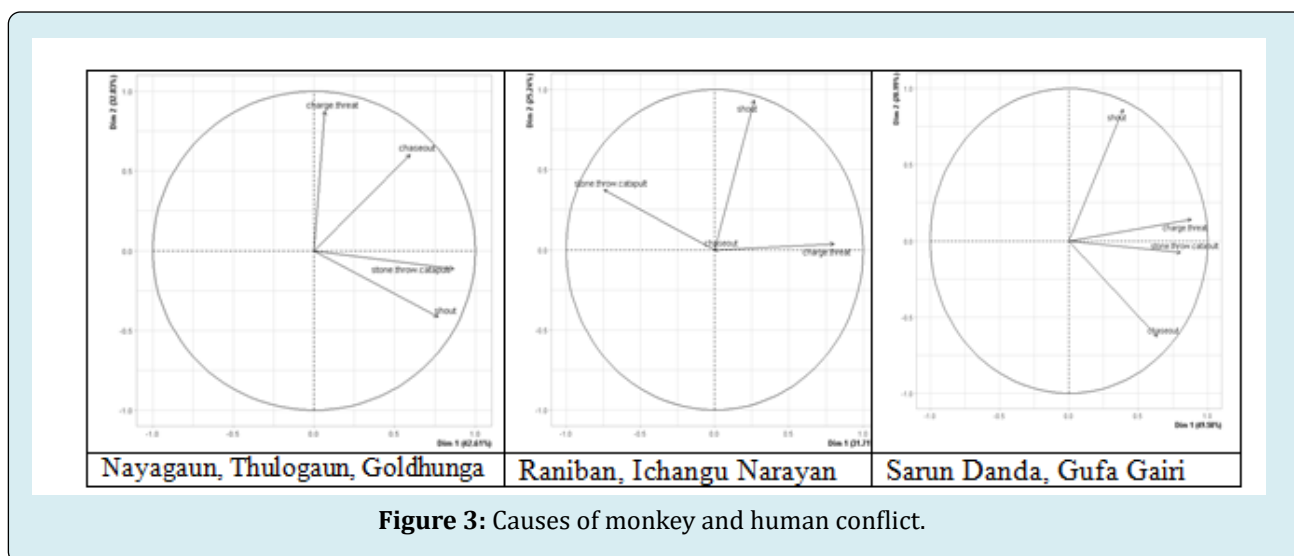


Figure 2: Spatial map for whole study area.

Causes of Monkey and Human Conflict

In the graph 3 of variable, the dimension 1, X-axis was 42.61% and dimension 2, Y-axis was 32.83%. The graph plot showed that the charged thread was maximum. The charged thread line in the graph plot at the origin was observed vertical i.e. nearly 80° with the X-axis and which made the angle around 10° with Y-axis. In the graph, the chase-out of monkeys in the site was less than charged thread, i.e. 45° with the both X-axis and Y-axis. It showed a positive

correlation between the charged thread and chased-out. These two actions have been borne by the positive region of the X-axis and Y-axis, more value than the other action i.e. stone throw, use of catapult, and shout. Similarly, the stone throw, use of catapult and shout has no any correlation with charged thread and chased-out, showed negative correlation because the stone throw, use of catapult and shout made the angle more than 90° with charged, thread and chased-out (Figure 3).



Further, when the Eigenvalues table was observed the variance of dimension 1 bore the highest value 1.704 and followed by dimension 2 with 1.31, dimension 3 with 0.558, and the smallest variance was with the dimension 4 0.424. The percentage of the variance was 42.611%, 32.833%, 13.959%, and 10.596% with dimension 1, dimension 2,

and dimension 3, dimension 4 respectively. The highest cumulative percentage was bored by dimension 4 was 100. The second-highest cumulative percentage was with dimension 3 89.40, dimension 2 bore 75.445, and the smallest was with dimension 1 42.611 (Table 3).

	Variance	% of Variance	Cumulative % of Variance
Nayagaun, Thulogaun, Goldhunga			
Dimension 1	1.704	42.611	42.611
Dimension 2	1.313	32.833	75.445
Dimension 3	0.558	13.959	89.404
Dimension 4	0.424	10.596	100
Raniban, Ichangu Narayan			
Dimension 1	1.268	31.705	31.705
Dimension 2	1.01	25.24	56.945
Dimension 3	1	25	81.945
Dimension 4	0.722	18.055	100
Sarun Danda, Gufa Gairi			
Dimension 1	1.983	49.583	49.583
Dimension 2	1.16	28.989	78.572
Dimension 3	0.536	13.402	91.974
Dimension 4	0.321	8.026	100

Table 3: Eigen values showing the causes of human monkey conflict.

The Table 4 showed that cause of monkey and human conflict. The some of the causes of monkey and human conflict

showed positive, negative and no correlation between them.

Principle Component Analysis	Action	Axis	Result
Causes of monkey and human conflict at Nayagaun, Thulogaun, Goldhunga	Charge threat, Chase-out, stone throw, catapult, shout	• Charge threat and Chase-out was in (+, +) axis	• Charge threat and shout showed no relation i.e., angle more than 90°
		• stone throw, catapult and shout were in (+, -) axis	• Chase-out with stone throw, catapult, shout showed relationship, where stone throw, catapult, shout has closer relation then with chase-out.
Causes of monkey and human conflict at Raniban Ichangu Narayan	Charge threat, Chase-out, stone throw, catapult, shout	• Charge threat, Chase-out and shout was in (+, +) axis	• Charge threat, Chase-out and shout showed close relation with each other.
		• stone throw, catapult was in (-, +) axis	• stone throw, catapult do not showed any relation with other action i.e. angle more than 90°
Causes of monkey and human conflict at Sarung Danda and Gufa Giri	Charge threat, Chase-out, stone throw, catapult, shout	• Shout and Charge threat was in (+, +) axis	• Shout and chase-out showed no relation i.e., angle more than 90°
		• Chase-out, stone throw, catapult as in (-, -) axis	• Charge threat, stone throw, catapult use and chase-out showed relation where Charge threat, stone throw, catapult showed too closer.

Table 4: Causes of monkey and human conflict at SNNP.

Discussion

Crop depredation caused by wild animals is serious issues in the world [15,16]. The results of this research demonstrate that site near the Shivapuri-Nagarjun National Park (SNNP), the two species of the monkey were found. The number of members in the troop was 15-20 and sometimes it was recorded 3-4 members or a single number. The highest number of Rhesus monkeys that were found in the residential area was due to the closer relationship with the crops to fulfill their food starvation. Rhesus monkeys were the more abundant of the two locally available species (128) and Langur's population was found to be 14 which may be due to his most sympathetic nature to human and crop attacks Aryal & Chalise [17]. The low number of Hanuman langur may be due to the small, green habitat of nature, which was less eternity to humans Khatry [18]. The number of mature individuals counted was 82 (56.9%) and 62 (43.1%) were immature individuals [19]. Their abundance in a particular area depends on the area's topography, forest types, vegetation patterns, and agricultural practices. Plantation of the new species of the plant in between natural forest which results from the shortage of food inside the national park, force the monkey to moves outside the national park in search of food. Planting exotic crops in place of natural food plants seem to have forced Rhesus monkeys to invade human settlements to survive Devi & Saikia [20]. Due to their intolerable activity; people today consider them pest species rather than important species of protection. Locals are even more concerned about the scale of the conflict over the next

few years, as they speculate that Rhesus monkey populations will not decline [20].

The household survey found the result that, the highest damage of the crop was recorded in Goldhunga, Nayagaun, Thulogaun, and that was more than 450 Kg. Corn is a staple food, a preferred crop, and less susceptible to other forms of damage. Several studies support that monkey like to eat and damage the crop [4]. Reported that grains, fruits, and tubers were the most preferred and vulnerable to macaque attacks in the Makalu-Barun Conservation Area [21]. Gathered crop looting information through an interview in Lakuwa village of the Makalu-Barun Conservation Area. Rhesus and Assamese macaques were the most common crop looters and Langurs were the least visited. Assamese monkeys were worse than rhesus monkeys [9]. Paudel (2016) recorded 61.18 ha of land used to grow crops at Kali Gandaki River Basin in Baglung and Parbat districts and the total yield of the crop would be 688.29 quintals, but it was only 567.74 quintal. In fact, 120.55 quintal maize was damaged by macaques [22]. According to the survey, macaques most commonly attacked rice (69%) and corn (59%), cardamom (44%), millet (28%), and others (15.4%) [23,24] reported wildlife attacks on buckwheat and barley in Langtang National Park and Rara National Park and also recorded monkey damage to crops on the southern border of the Makalu-Barun Reserve (MBCA) [25,26].

The human and monkey conflict consequence several loss that were varying in quantity and money [27,28]. The economic loss of 39 households was approximately \$

23,477.90 annually with an average of \$ 602 per household (equivalent to NPR 60,199.74) [29]. Most respondents shared that around 32% loss was due to the wild animals in maize, its value ranged from US 20, 0 to 5000 [30]. These findings were quite similar with the result of this research.

To achieve a better understanding of the spatial distribution patterns of damaged crops in Nayagaun, Thulogaun, Tarakeshwor-3 showed the extreme damage of the crops i.e. maize in one site and other was addressed moderate damage of the crops. In Tarakeshwor-5 Gol Dhunga 21 spot was recorded as the low damage of the crops then the Tarakeshwor-3. In Gufagairi, Sarung danda, Nagarjun-1. The damage and loss caused by the wild animals distributed according to the nature of animals and monkey generally like maize, wheat and fruits [31,32]. This research showed that, damage caused by the monkey was commonly at maize field. There is no only one reason of monkey and human conflict but it is generally because of searching of food [33-35].

Principle component analysis showed the trend of the damage of the crops and monkey activities in the studied site. In Nayagaun, Thulogaun, Sarung Danda, Ghufa Gairi, and Raniban, Ichangu Narayan different data have been found from the house survey data collection. The result found with the Raniban, Ichangu Narayan shout and charge threat showed positive relation where the stone threw by catapult and chase-out have negative relation. People defended themselves against monkeys in a variety- and through a combination- of actions i.e., most often involved throwing stones or using a catapult (30%), shouting or throwing a firecracker (54%), or encouraging their dogs to chase monkeys (9%) and about 1% did nothing or tolerated the monkeys [36,37]. Guards (93%) and slingshot/bow and stone or stone use (89%) are most commonly used to chase the monkey Barua [38]. Human Wildlife conflict is serious issues so as found in this park as well [39-42].

Conclusion and Recommendation

The highest damage of the maize was found at Nayagaun, Thulogaun while this was the lowest at Raniban, Ichangu Narayan while medium damage was recorded at Naagarjun, Gufagairi, Sarung danda. The maize damage distribution was categorized into highest, medium and lowest group. The highest damage of maize was distributed dominantly at Thulogaun. Similarly, medium damage was distributed at Sarung Danda while lowest damage was distributed at Raniban area. Principle component analysis showed the trend and triggered the highest level of conflict and the action factor between humans and monkeys. The factors are use of catapult in Nayagaun, Thulogaun, shout and charge threat in Naagarjun, Gufagairi, Sarung danda and in Raniban, Ichangu Narayan. This research will be useful for scientific

community and policy maker.

The distance from the national park area does not affect the harvest pattern, so an alternative harvesting system may be a better option. Priority should be given to maximize the alternative farming like chilli, garlic, onion, turmeric, and others fruits etc. The preferred species of monkey like plantation of fruits should be given high priority manage the conflict between monkeys and human.

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